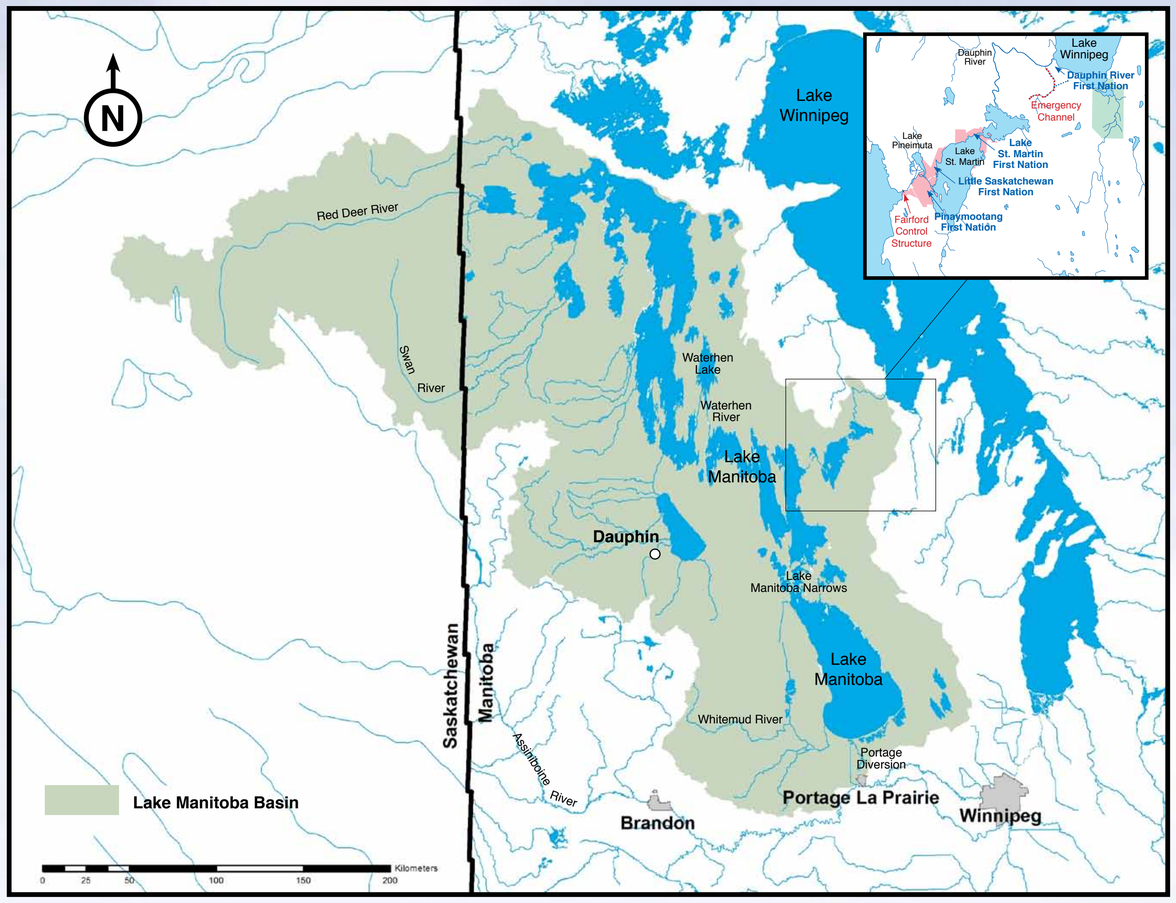
Technical Background - Lake Manitoba Basin

Lake Winnipegosis, Lake St Martin, and Lake Winnipeg via Dauphin River



Lake Manitoba Basin Area Map

Lake Manitoba has a surface area of 4,740 km^2. It drains an area of 79,900 km^2 that includes the east side of the Riding Mountains and most of the Duck and Porcupine Mountains. Runoff from the Duck and Porcupine Mountains finds its way into Lake Manitoba via the Waterhen River after passing through Lake Winnipegosis and Waterhen Lake.

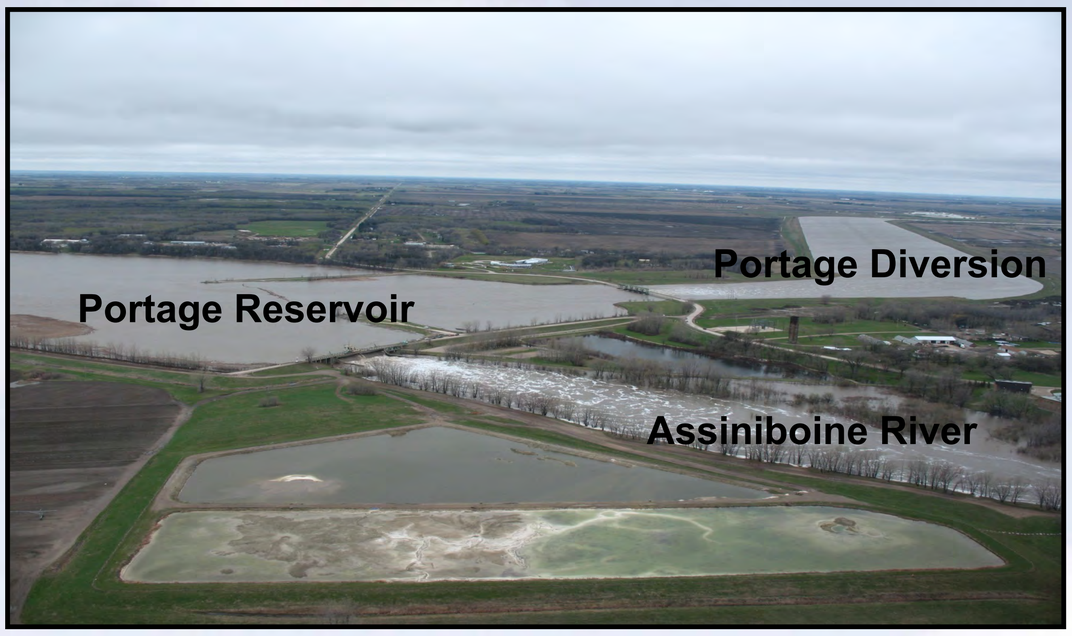
Lake Manitoba also receives inflow via the Portage Diversion when flows are high on the Assiniboine River and high flood levels are imminent at Winnipeg. Inflows into Lake Manitoba can be well established by considering flows on the Waterhen and Whitemud Rivers and by accounting for flows at the Portage Diversion at Portage la Prairie.

The Waterhen River is the main tributary to Lake Manitoba. It drains about 55,000 km^2, or about 70% of the total Lake Manitoba drainage basin. However, flows on the Waterhen River are naturally regulated by storage in Lake Winnipegosis.

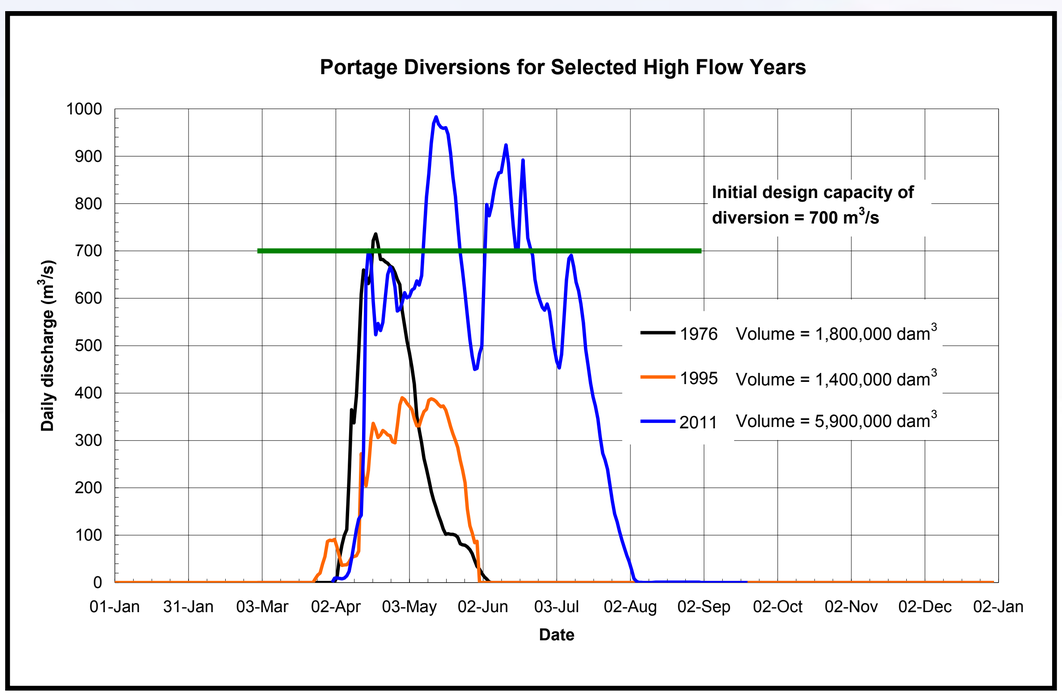
The Fairford River provides the only outflow from Lake Manitoba, and it is regulated by the Fairford Control Structure. It conveys flows into Lake St. Martin (surface area of 345 km^2) which connects to Lake Winnipeg via the 50 km long Dauphin River. Outflows on the Fairford River are severely limited by water levels on Lake St. Martin and the winter capacity of the Dauphin River. An emergency channel has been constructed between Lake St. Martin and Lake Winnipeg to augment the capacity of the Dauphin River and there are considerations to construct a channel between Lake Manitoba and Lake St. Martin to add to the capacity of the Fairford River.

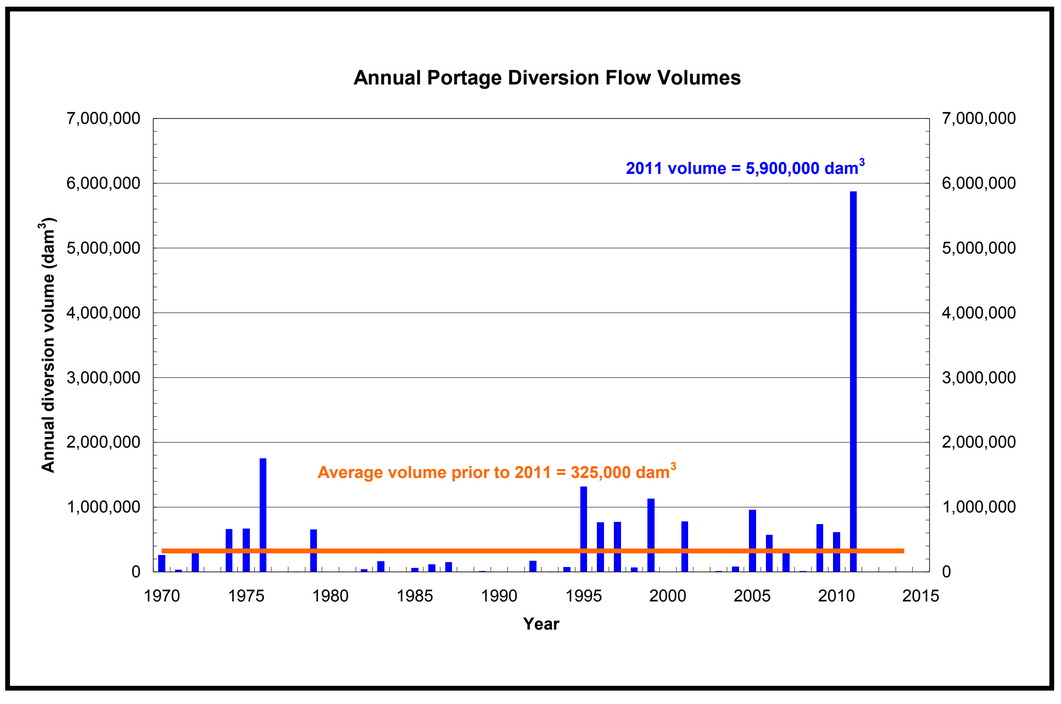
Technical Background - Lake Manitoba Basin

The Portage Diversion



Portage Diversion on May 11, 2012 when the flow into the Portage Reservoir was 1,412 m^3/s and 862 m^3/s was being diverted into Lake Manitoba.





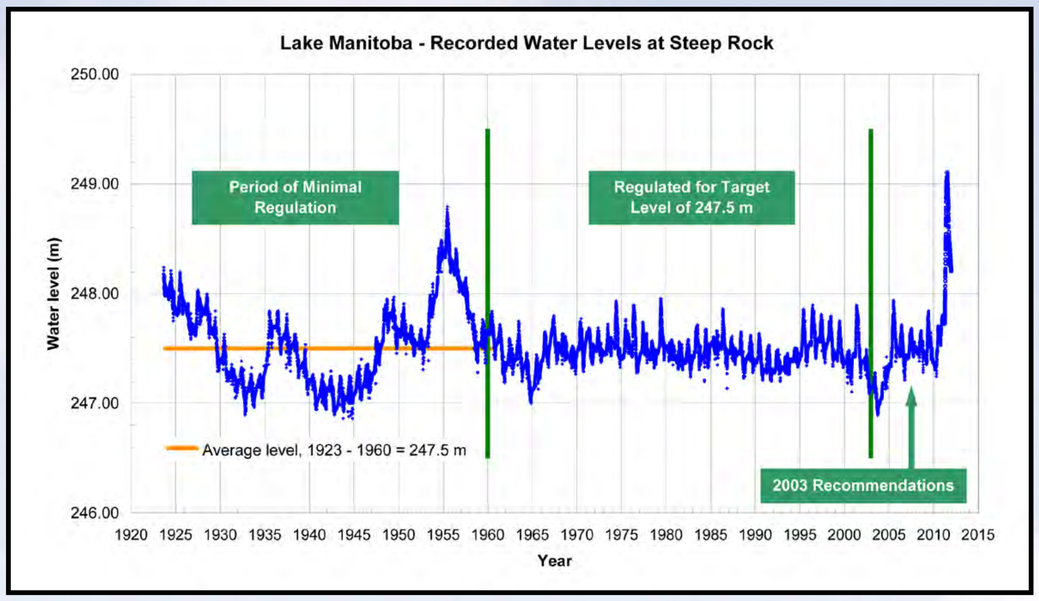
The Portage Diversion was completed in 1970. It is one component of the works constructed in the 1960's to prevent flooding in Winnipeg. The Diversion consists of two separate control structures: one which controls the flows down the Assiniboine River and another which diverts some of the flow of water in the Assiniboine River into a 29 km long diversion channel that empties into Lake Manitoba near Delta Beach. The diversion was originally designed to carry a maximum flow of 700 m^3/s.

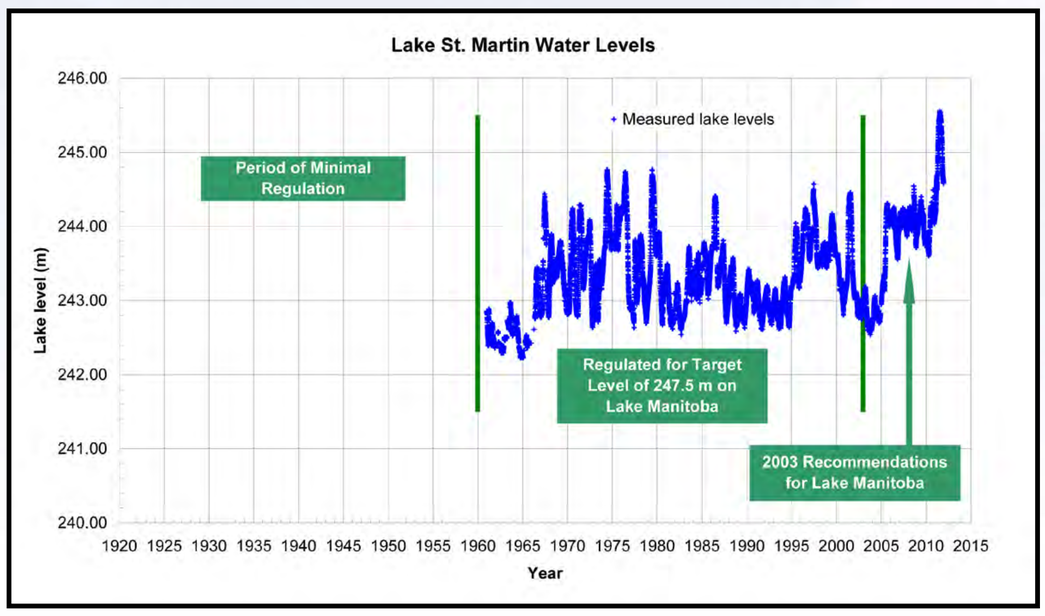
To prevent the Assiniboine River dikes from breaching and flooding much of the prairie between Portage and Winnipeg, the Manitoba authorities, under a state of emergency, raised the dikes along the diversion channel to accommodate a flow of about 1,000 m^3/s. The diversion flow averaged about 710 m^3/s over a period of about 15 weeks, peaking at 983 m^3/s on May 14. The resulting volume diverted to Lake Manitoba was 5,900,00 dam^3 or more than three times the next highest volume that occurred in 1976.

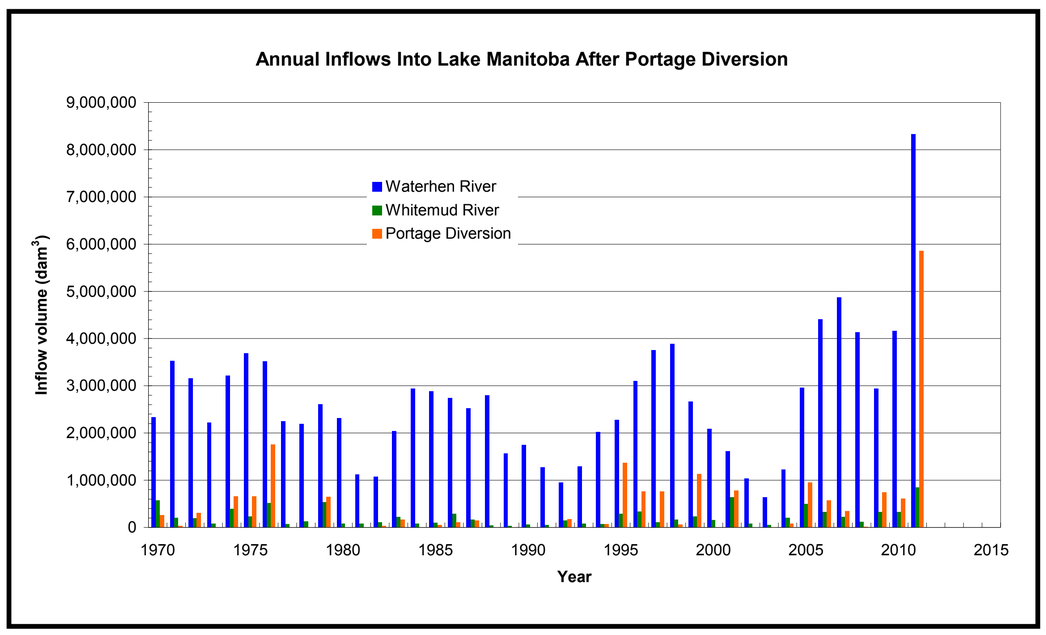
In 2011 the Portage Diversion was operated for a period of 130 days. In early May 2011 forecasters predicted a record flood volume with a peak flow of over 1,400 m^3/s on the Assiniboine River at Portage la Prairie. The expected dike capacity of the Assiniboine River downstream of Portage la Prairie was only about 500 m^3/s due to geotechnical considerations.

Technical Background - Lake Manitoba Basin

Historical Water Levels on Lake Manitoba







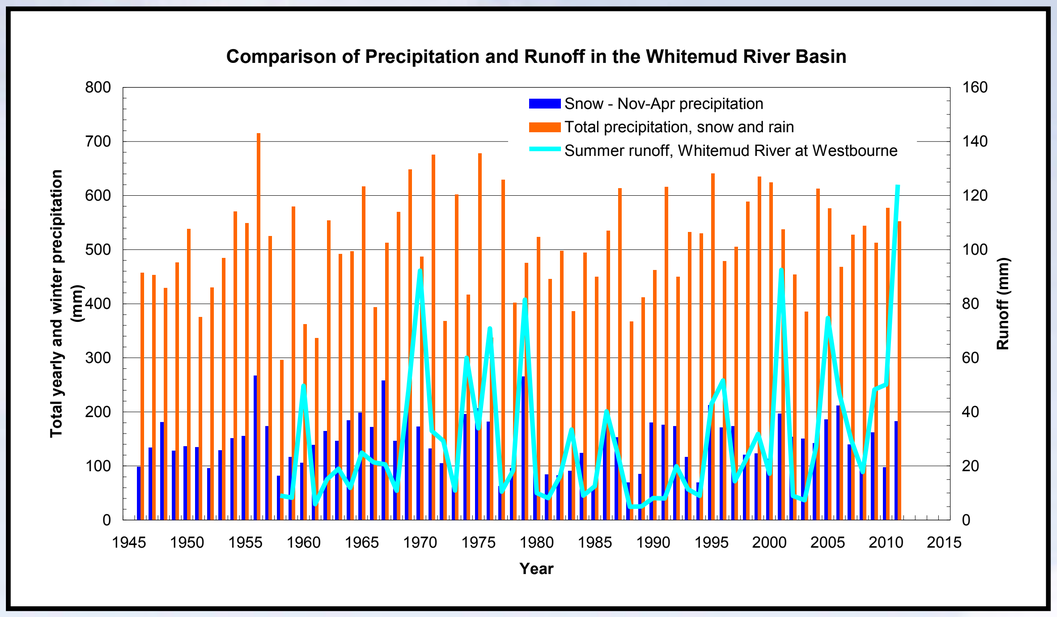
Although some attempts were made to regulate Lake Manitoba levels as early as the 1880's they had minimal impact on lake levels until the Fairford Control Structure was constructed in 1960. Before 1960 the lake fluctuated naturally over multi-year cycles. However the Fairford Control Works allowed the operators to maintain Lake Manitoba levels within a narrow range. This operation resulted in wider and more frequent fluctuations on Lake St. Martin a few kilometres downstream.

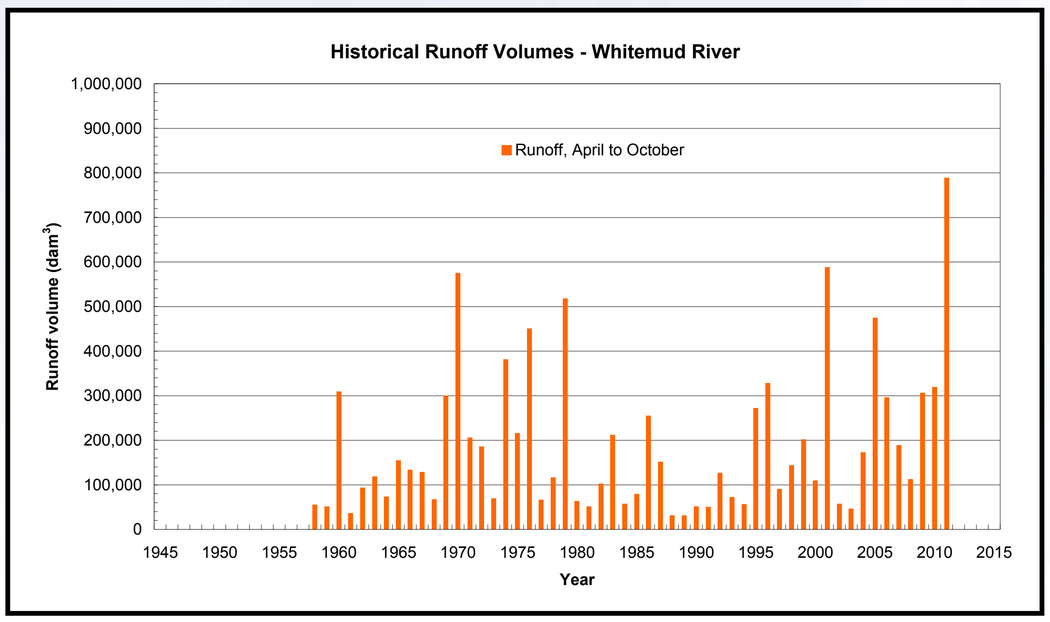
The July 2003 report of the Lake Manitoba Regulation Review Advisory Committee recommended that Lake Manitoba be regulated in a more natural fashion. They recommended that when both lakes are within a "normal" range no adjustments be made to the control structure. When either or both lakes are outside their desirable ranges the lakes should be regulated to balance the impact on both lakes. The government of Manitoba adopted these recommendations.

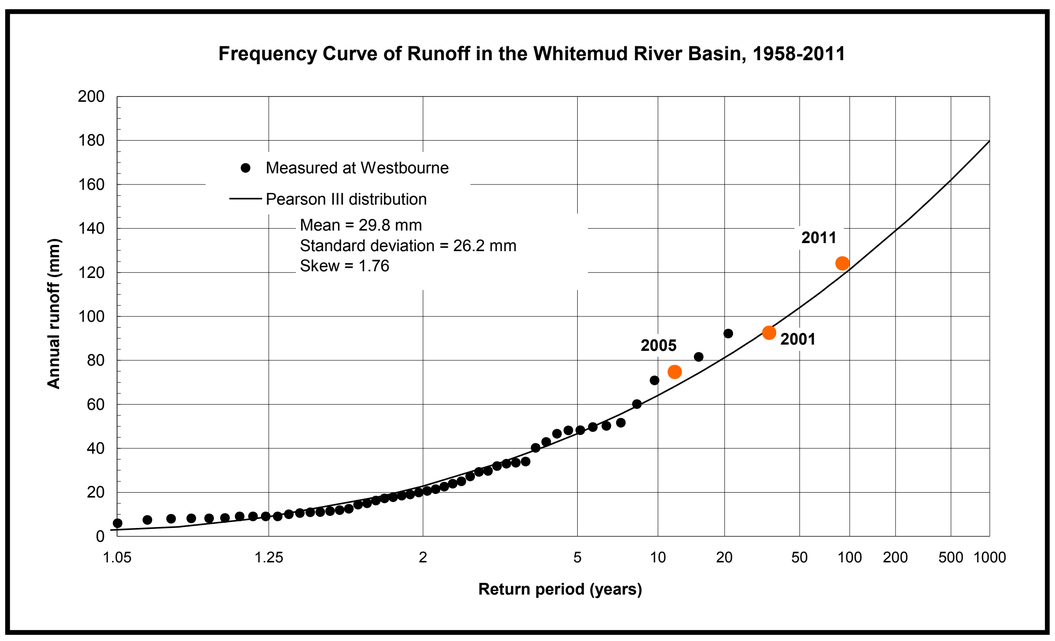
In most years the major source of inflow to Lake Manitoba is the Waterhen River. The Waterhen River shows multi-year cycles of dry and wet periods that are evident in the plot of Lake Manitoba levels before 1960. Waterhen River flows from Lake Winnipegosis were above average every year from 2005 to 2010. By the fall of 2010 Lake Winnipegosis levels were the highest levels in 50 years, thereby guaranteeing above average Waterhen River flows in 2011. The high Lake Winnipegosis levels in 2010 coupled with the record high inflows to Lake Winnipegosis in 2011 resulted in the highest Waterhen flows on record.

Technical Background - Lake Manitoba Basin

Whitemud River Natural Flows



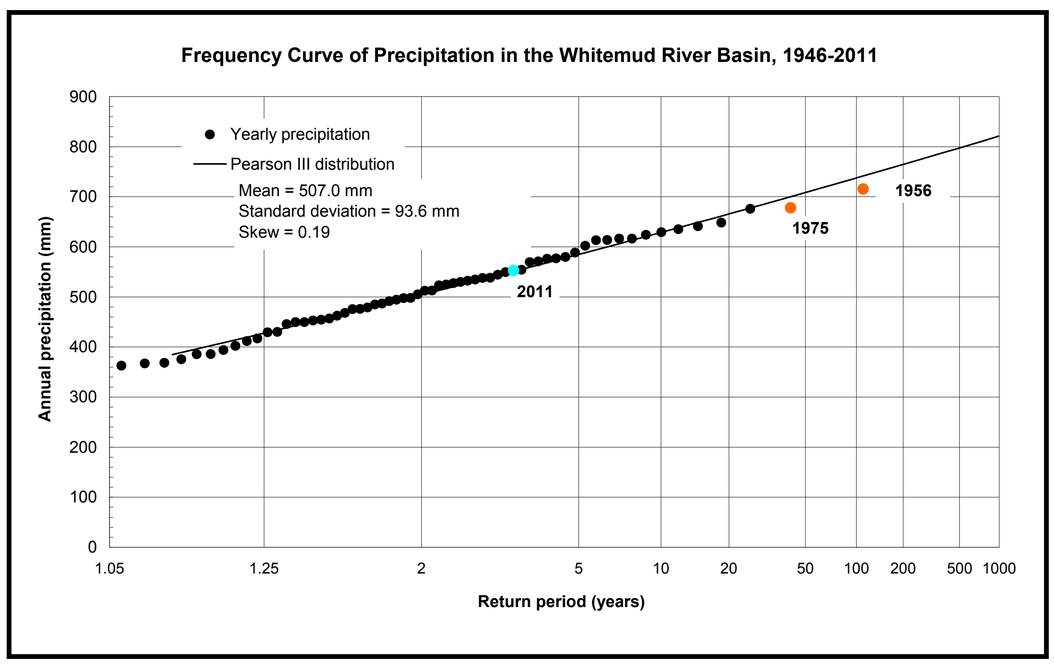




The Whitemud River provides a reasonable analogue for the contribution of the ungauged catchments around the southern extent of Lake Manitoba. Precipitation in the Whitemud River basin in 2011 was about 550 mm - slightly above the long term average and corresponded to something less than a 5-year return period. Previous years with the large amounts of precipitation were 1956 and 1975.

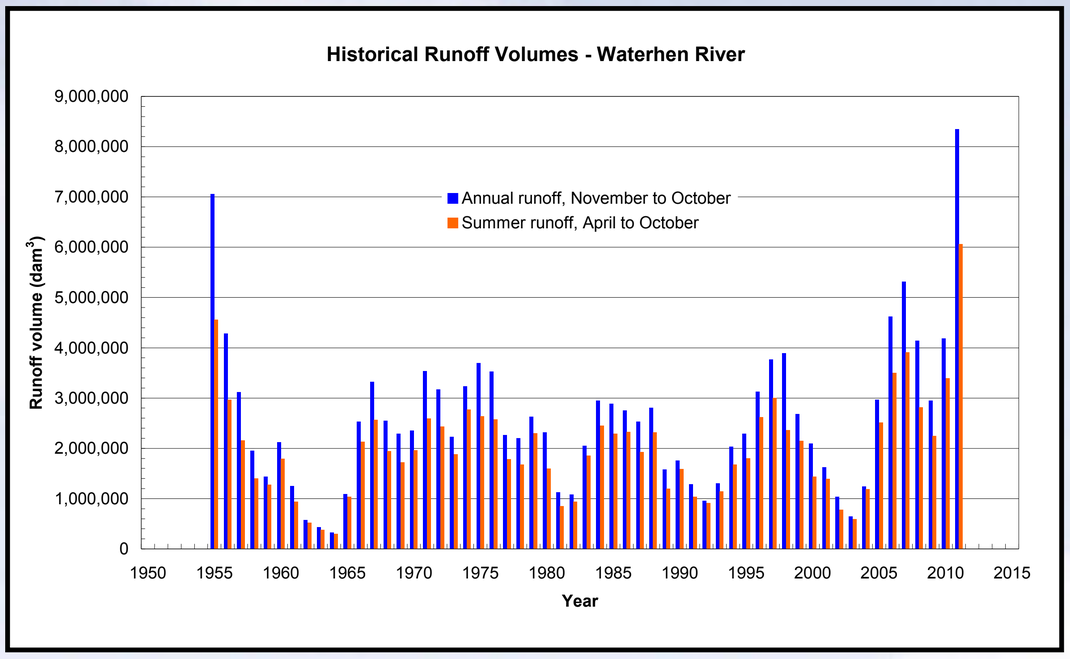
The annual runoff volume in 2011 was the largest on record – some 850,000 dam^3. This eclipsed the 1970 and 2001 runoff volumes by about 30 percent. The wet periods in the early 1970s, the mid 1990s, and the 2010s (extending into 2011) are evident, along with the dry periods in the early 1960s and the early 1980s.

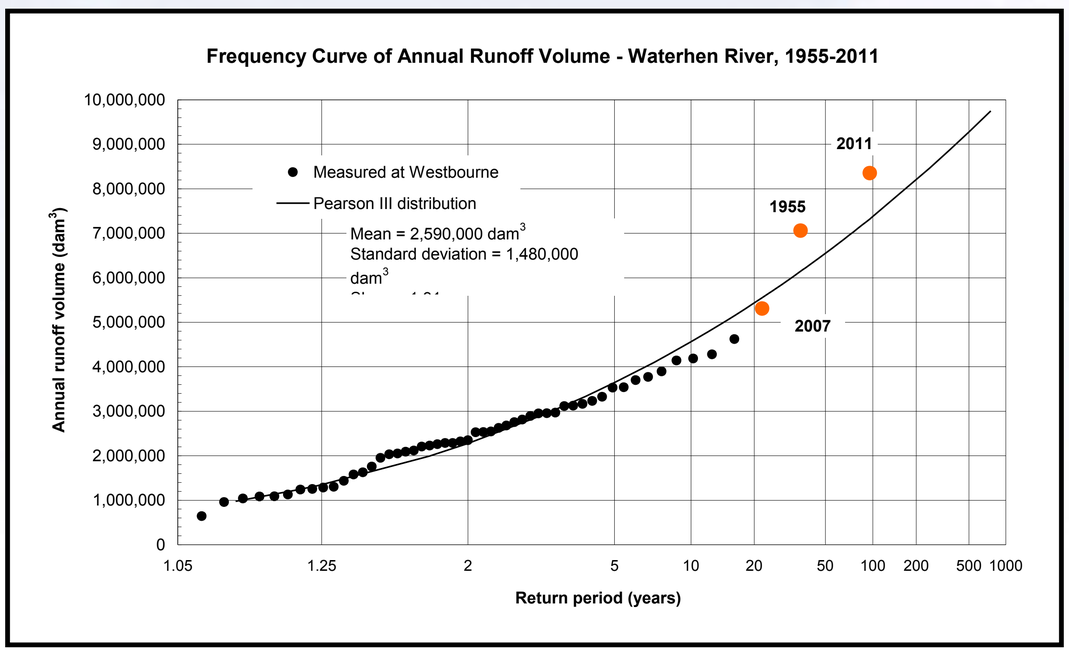
In 1975 only about 5 percent of the precipitation was converted to runoff – in 2011 it was about 23 percent. In 2011, high antecedent moisture conditions resulted in a high percentage of the precipitation being converted to runoff due to a lack of storage in the basin. The 2011 runoff volume from the Whitemud River basin was about a 100-year event.



Technical Background - Lake Manitoba Basin

Waterhen River Natural Flows



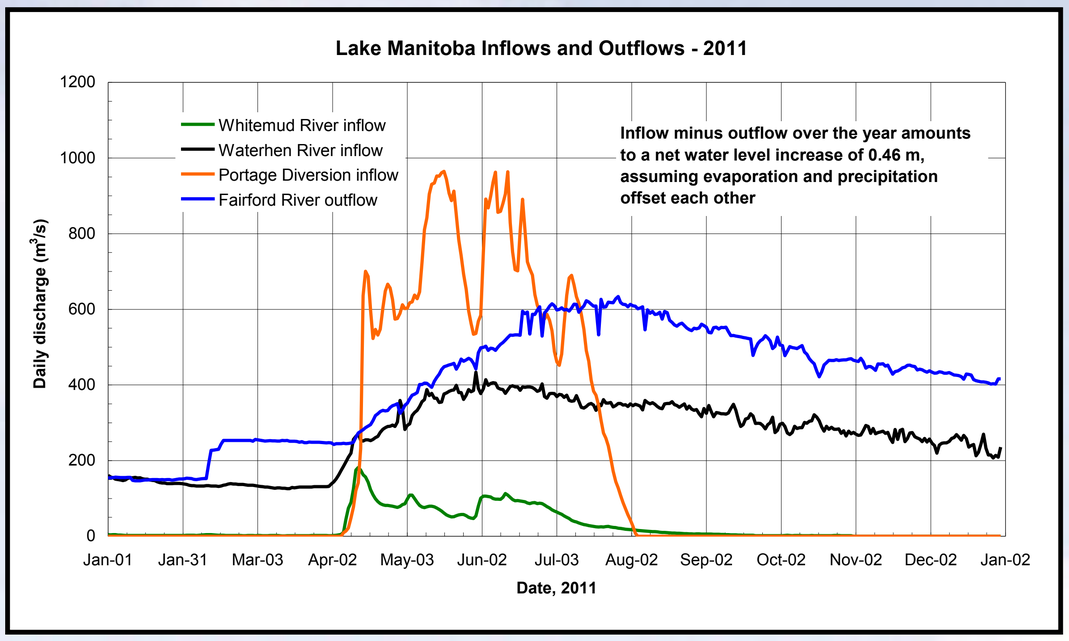


The Waterhen River is the main contributor to flows into Lake Manitoba and inflows from the Waterhen reflect water levels on Lake Winnipegosis. The Waterhen River flows were the highest on record in 2011 – about 3.2 times the historical mean flow. The 2011 runoff volume eclipsed the 1955 volume by about 20 percent.

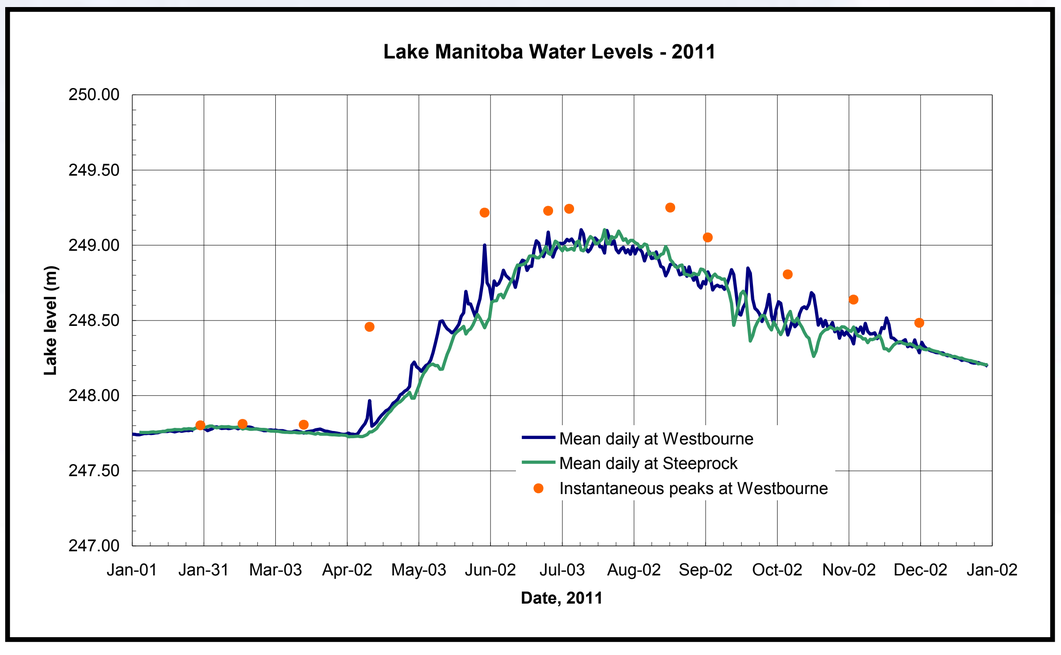
The effects of storage in Lake Winnipegosis is evident in the cyclic type of response of the Waterhen River to wet and dry periods. The period between 1955 and 1964 was dry and subsequently the Waterhen River flows decreased to record low levels. Between 1965 and 1975 there was a 10 year span when outflows were about average. Flows were more or less in the average range in the mid 1980s, and the late 1990s, punctuated by below- average flows in the early 1980s, early 1990s, and early 2000s.

In the period leading up to 2011, flows typically were above average, setting the stage for high antecedent lake levels. In retrospect, the 2011 runoff volume proved to be about a 200-year event. As is evident in the flow pattern after 1955, it is likely that the Waterhen River will continue to contribute above average flows for the next couple of years, even if precipitation is at or below average.

Lake Manitoba Water Levels



Inflows to Lake Manitoba were the highest on record for both the Waterhen River and Portage Diversion. Inflows peaked in early June at about 1450 m^3/s. Outflows through the Fairford Control Structure peaked at 646 m^3/s in late July, coincident with peak lake levels, and continued to recede well into 2012. In 2011 ambient levels on Lake Manitoba peaked at 249.1 m in late July. Instantaneous peaks due to wind effects were typically about 0.25 to 0.50 m above the ambient lake level, and these occurred virtually in every month.

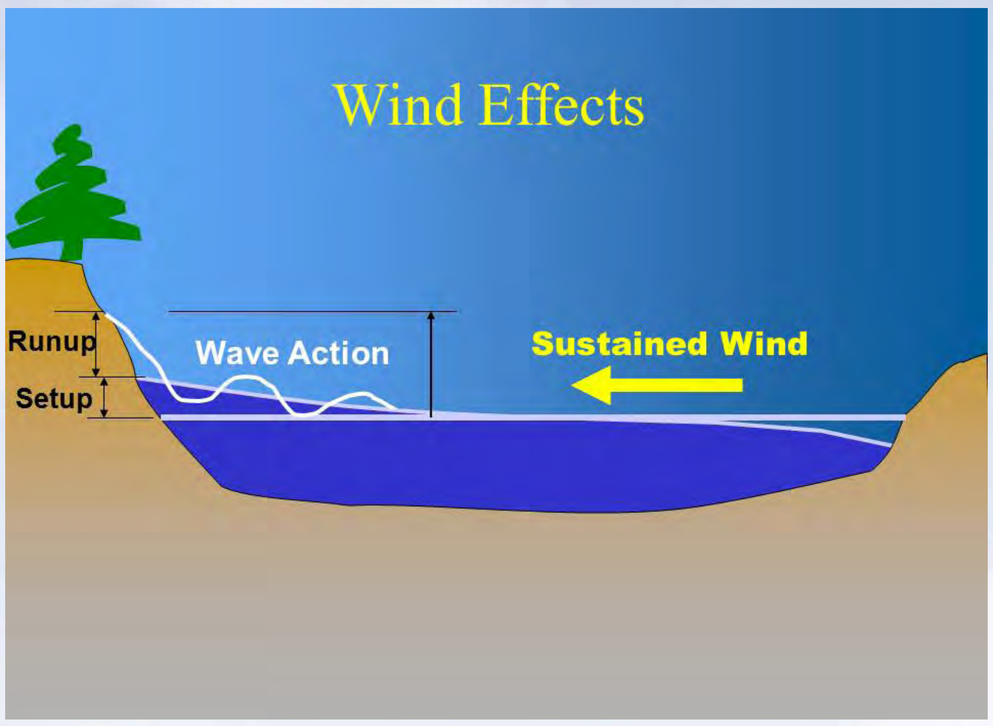


Between January and early April, lake levels were relatively steady as outflows at Fairford kept pace with the winter inflows derived primarily from the Waterhen River. In the second week of April, levels began to increase rapidly due to rising inflows from the Waterhen River, the Whitemud River, and the Portage Diversion.

Because of persistent high inflows (mostly from the Waterhen River) the Fairford Control Structure has been kept effectively open from August 2005 until the present. The only exceptions were the winter flow reductions to 140 m^3/s to prevent ice-related flooding along the Dauphin River – invoked from November 12, 2007 until February 4, 2008, and again from October 14, 2008 until February 6, 2009. In the fall of 2010 Fairford flows were above 200 m^3/s, but Lake Manitoba levels were high, and indications pointed to the potential for flooding in 2011. A decision was made to cut back Fairford flows because if frazil ice blocked the Dauphin River high spring flows would cause extensive flooding on Lake St. Martin. Therefore the flows were cut back in the period from November 15, 2010 to February 11, 2011.

Technical Background - Lake Manitoba Basin

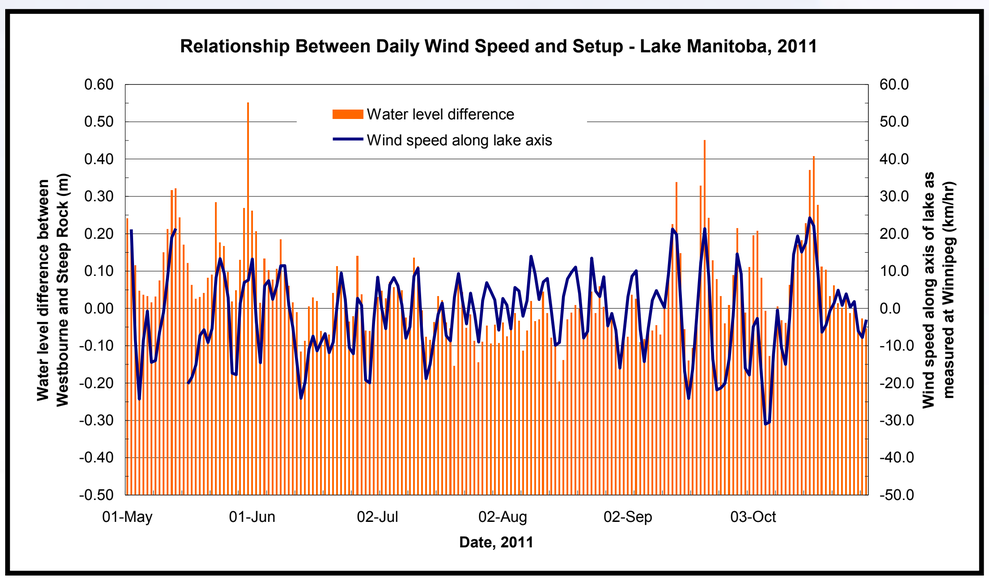
Effects of Wind: The May 31 Storm

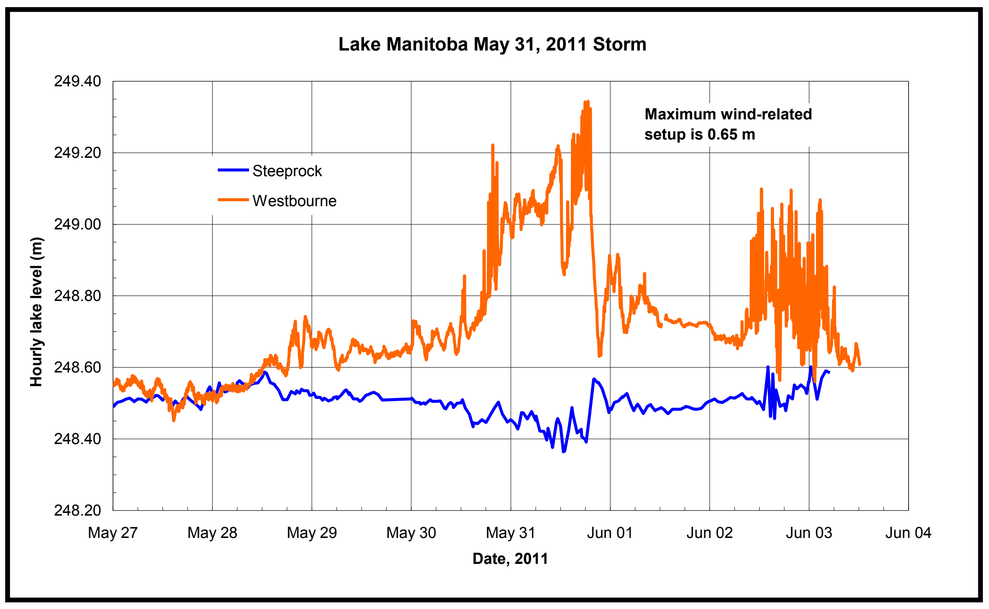


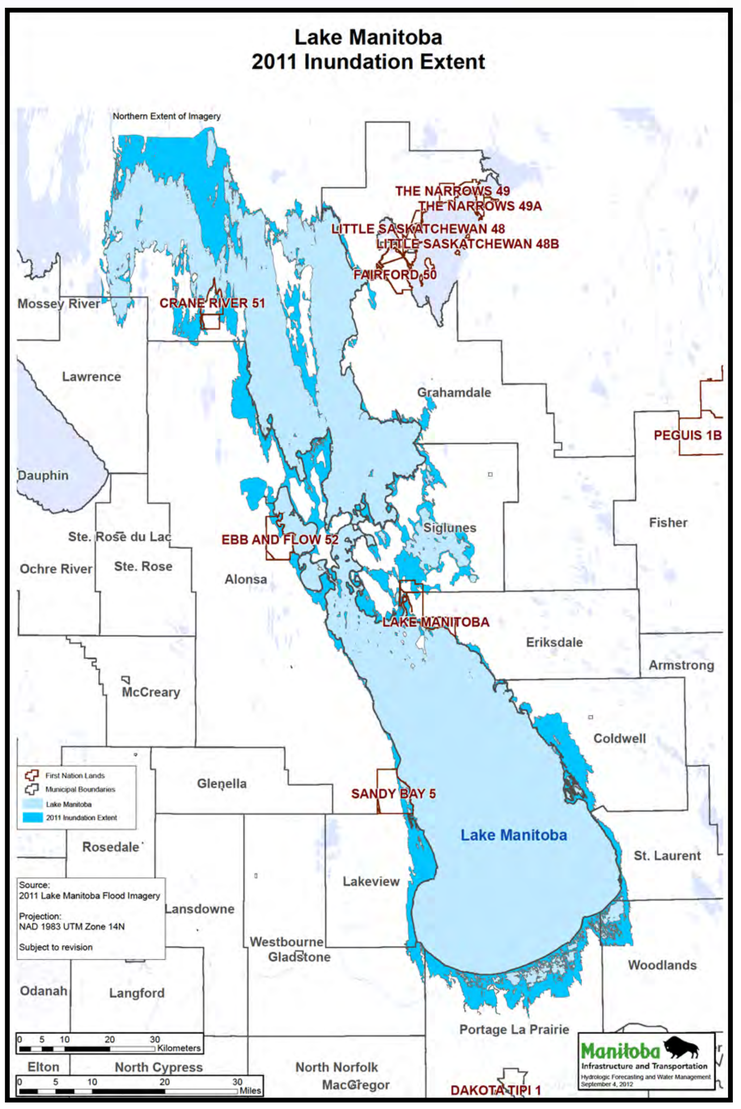
Given the predominantly northwesterly winds that are experienced in the region, there is potential for high wind-related water levels to occur along the southern margins of Lake Manitoba due to both lake setup and wave runup.

Wind and water level data indicates that there is a strong correlation with wind speed in the direction along the lake and water level differences between Steep Rock and Westbourne. Sustained winds of 20 km/hr can produce a water level differential of 0.2 to 0.4 m.

On May 31, severe winds in excess of 100 km/hr from the northwest produced a setup of 0.65 m at Westbourne – raising the lake level there to 249.35 m. The instantaneous peak level at Twin Lakes Beach reached 250.04 m, almost 1.5 m above the calm lake level. Waves as high as 2.1 m were reported against dikes and buildings. Areas around the lake that were hardest hit include the Rural Municipalities of St. Laurent, Woodlands, Alonsa, Portage La Prairie, and the First Nation communities of Lake Manitoba and Sandy Bay.

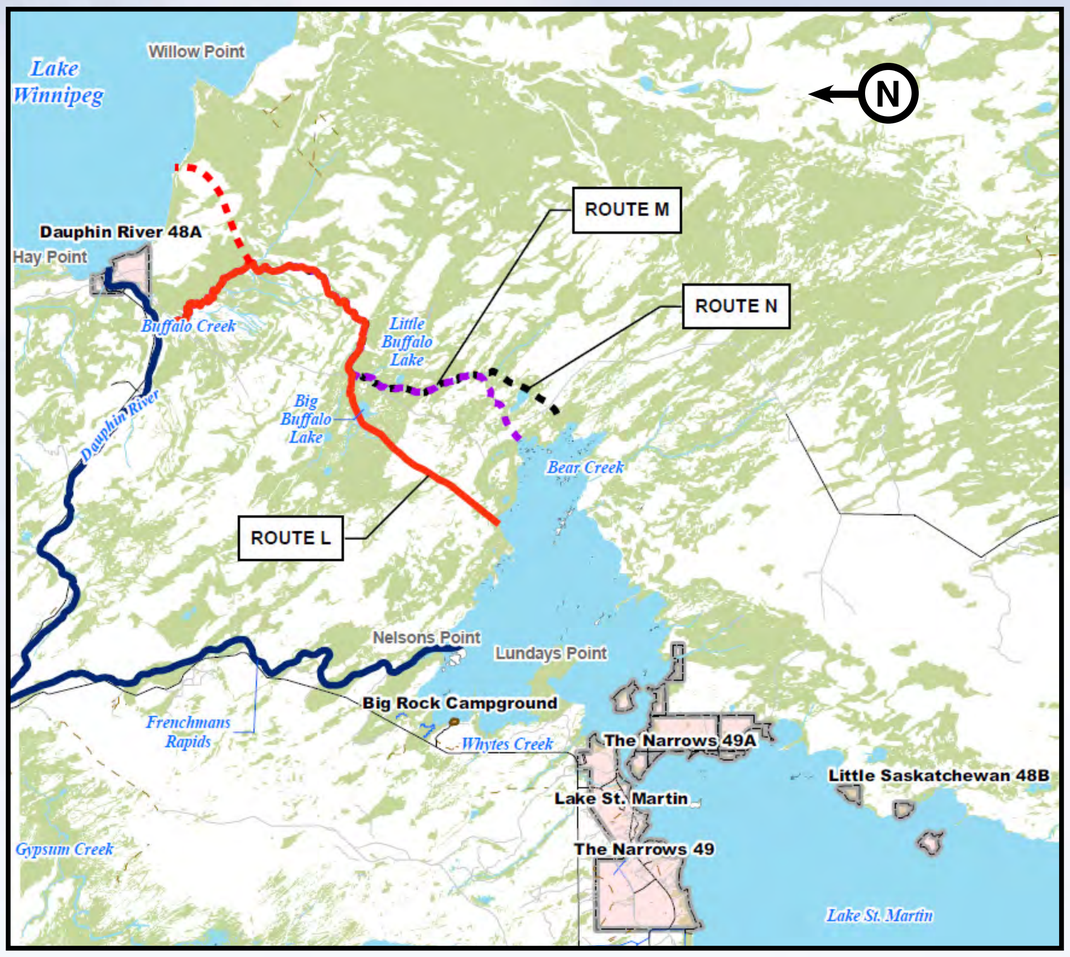






Technical Background - Lake Manitoba Basin

Mitigation Measures: The Emergency Channel



Ice conditions on the Dauphin River limit winter outflows from Lake St. Martin and increase the probability of winter flooding at the community.

During the summer of 2011 it was recognized that frazil ice would again become a problem on the Dauphin River over the winter of 2011-12. To alleviate this problem an emergency channel was constructed from the northeast end of Lake St. Martin to the lower Dauphin River (Route L) and put into operation on November 1, 2011. The channel has a capacity of 100 m^3/s when Lake St. Martin is at a level of 244.0 m. With the emergency channel in place there was no need for a severe winter flow curtailment at the Fairford Control Structure.

If the emergency channel had not been constructed flows through the Fairford Control Structure would have been reduced over the winter period. Lake level simulation indicate that levels on Lake Manitoba in the summer of 2012 would have been 0.4 metres higher than recorded, and summer levels on Lake St. Martin would have been 0.5 metres higher.

If Fairford had been kept open all winter before the 2011 flood, lake level simulations suggest that the peak level on Lake Manitoba would have been 0.03 m (three centimetres) lower. The emergency channel would have lowered the 2011 Lake St. Martin peak level by 0.5 m. It is apparent that the capacity of the emergency channel is insufficient to provide significant relief in the short term during events like 2011. However, it may have some positive effects for less severe floods. Analysis to confirm these effects is still ongoing. It may be that in its present configuration the emergency channel can prove to be valuable over the long term if it is used in combination with a relaxed Lake Manitoba water level regime.